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14 May 2014

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CPT Richard S. Carlile
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Date: **05/13/2014**

A comparison of marginal fit between lithium-disilicate press and CAD fabricated crowns

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Disclaimer

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Statement of problem. There are no current articles comparing the marginal fit between pressed lithium-disilicate and CAD lithium-disilicate full-coverage crowns.

Purpose. The purpose of this study was to compare the marginal fit of lithium-disilicate press crowns with lithium-disilicate CAD crowns to determine if fabrication method has an influence on marginal fit.

Material and methods. Marginal fit of 25 press and 25 CAD crowns were obtained using the replica technique. The sites measured were the mesial, distal, facial, and lingual margins. A microscope at 10x was used to obtain the measurements with the use of a micrometer. Each site was measured four times and intraclass correlation coefficients were used to assess measurement errors. An unpaired t-test was used to evaluate differences between the two groups.

Results. Mean marginal gap measurements were higher for CAD crowns compared to press crowns at all sites. Mesial margins were 53 μm for CAD, 46 μm for press. Distal margins were 53 μm for CAD, 50 μm for Press. Facial margins were 73 μm for CAD, 45 μm for press. Lingual margins were 61 μm for CAD, 49 μm for press. Only the facial margin had a statistically significant difference when comparing measurements ($p<0.001$).

Conclusion. Lab fabricated lithium-disilicate crowns provide better marginal fit than those fabricated by CAD/CAM, but both fabrication methods provide crowns whose marginal fit is clinically acceptable.

Introduction

The use of computer-aided design/computer-aided manufacturing (CAD/CAM) to fabricate crowns has increased since systems first came on the market in the early 1990s.[1,2] CAD/CAM has several advantages including same-day delivery and no impression materials. One of the disadvantages of CAD/CAM equipment is price.[1] Also, marginal fit of first

generation CAD/CAM crowns averaged 150 μm to 250 μm.[1] Since then, CAD/CAM technology has continued to improve. Most studies comparing marginal fit of CAD/CAM restorations report clinically acceptable results.[3-11]

The ideal cement width per ANS/ADA specification no. 8 for zinc phosphate cement is 25 to 40 μm.[12] Studies have shown this ideal width to be unrealistic.[1,3] In 1971, McClean and von Fraunhofer[13] concluded that a marginal gap/cement film of less than 120 μm would achieve clinical success. Since then, numerous studies have used either 100 or 120 μm as the marker for clinical success when measuring marginal fit.[3,6-11]

The replica technique was first described by McLean and von Fraunhofer as a way to measure marginal fit.[13] Originally polyether rubber was used, but most studies now use light body vinyl polysiloxane (VPS) to measure the marginal gap. Tsitrou et al[11] reported the replica technique to be a reliable method of measuring marginal gap.

Lithium-disilicate is an all-ceramic material that can fabricate crowns via a heat-press process (lab fabricated) or a CAD/CAM block. Advantages of lithium-disilicate are its esthetics, acceptable strength, and good survival rate.[14] Gehrt et al[14] reported a 97.4 % survival rate after 5 years and 94.8% survival rate after 8 years of 94 lithium-disilicate crowns. Guess et al reported a 100% survival rate 7-years for 40 lithium-disilicate pressed crowns.[15]

To date, there have been several studies comparing marginal fit of CAD/CAM and pressable ceramic restorations.[4,5,8-10] They all conclude that lab fabricated ceramic restorations have a better marginal fit than CAD/CAM, but both restorations produce marginal gaps within the clinically acceptable limit. To the authors' knowledge, there are no studies that have compared the marginal fit of lithium-disilicate press and CAD full coverage crowns.

The purpose of this study is to compare the marginal fit of lithium-disilicate pressable to CAD/CAM fabricated crowns. The null hypothesis is that there is no difference in marginal fit between lithium-disilicate press and lithium-disilicate CAD crowns.

Materials and Methods

Holmes et al[16] defined marginal gap as, "the perpendicular measurement from the internal surface of the [crown] to the margin." This definition was utilized in the current study as the basis for measuring marginal fit. A metal die was fabricated from a VPS mold (Examix NDS Light and Heavey Body, GC) of an ideal lithium-disilicate crown preparation (e.Max, Ivoclar Vivadent).

Renne et al.[3] performed a study in which they compared how preparation design affected the marginal fit of restorations. A visual rating was utilized to determine whether each preparation was excellent, fair, or poor. Those in the excellent group were 25 crowns and had an average marginal fit of 38.5 μm and had a standard deviation of 9.

The research article by Renne et al[3] was utilized in the current study to help determine the sample size. Since the metal die cast was considered in the excellent category of the Renne paper[3], the sample size was determined to be 25 per group. With 25 samples per group and letting alpha=0.05 the current study was designed to have 80% power to detect a difference of 7.3 μm in marginal gap between the CAD and press fabricated crowns, assuming a standard deviation of 9 as seen in the Renne et al study.[3]

The metal die was impressed and poured in a scannable Type IV gypsum stone (FujiRock EP OptiXscan, GC). 25 lithium disilicate CAD crowns were fabricated using the CEREC inLab MC XL inLab software version 3.88. 25 lithium disilicate press crowns were fabricated by an

experienced lab-technician. All steps in the impression, stone pouring, and fabrication process were performed according to manufacturer recommendations.

The replica technique was utilized to measure marginal gap. Each crown was cemented on the die with light body VPS (Examix NDS light body, GC). Following removal of the crown from the die, the light body was stabilized with an occlusal bite registration VPS (Blu-Mousse, Parkell). Each replica was sectioned in four areas with a razor blade to allow measurements of the mesial, distal, facial, and lingual margins. See Figure 1.

Marginal gaps were measured under an Olympus BX45 at 10X magnification using a micrometer. Each site was measured four times and averaged for analysis. Intraclass correlation coefficients (ICC) were calculated to assess the reproducibility of the 4 replications, and a two-sided unpaired t-test design was used to compare mean marginal gap between CAD and press crowns at each of the four locations. A significance level of 0.05 was used for all tests, with a Bonferroni adjustment for the four comparisons. All analyses were done using SAS software version 9.2, SAS Institute, Cary, NC.

Results

The results of the marginal gap measurements are presented in Table I. Figure 2 illustrates the measurements according to site. The mean marginal gap was higher for the CAD crowns compared to the Press crowns at all tooth locations, but the only significant difference was at the facial margin (73 μm vs. 45 μm, $p<0.001$). The lingual margin had a difference of 24% (61 μm vs. 49 μm), which is higher than the proposed clinically significant difference of 20%, but p-value was only marginally significant ($p=0.058$). ICCs for each site are presented in Table 2. ICCs ranged from 0.82 to 0.92 across the four sites, indicating that measurement error accounted for 10-20% of the variability in the marginal gap.

Discussion

The null hypothesis of this study was rejected due to the statistically significant difference in the facial margin as well as the marginally significant difference in the lingual margin. Fabrication method (CAD/CAM vs. lab fabrication) has an influence on marginal fit. It is important to note that while there was a difference in marginal gaps, both fabrication methods produced marginal gaps less than 120 μm.

One potential explanation for the significant difference at the facial margin could have been a misplaced margin on the facial surface. While indicating the margin on the software program, it is entirely possible that the location of the margin could have been misread and marked above the true margin. This could be considered a potential disadvantage of the CAD/CAM fabrication process. Future studies could investigate the amount of variability in margin design on the same preparation between different practitioners.

Use of the replica technique has been touted as an accurate method of measuring marginal gap.[3,5,11,13] This study, unlike previous studies[3,11], utilized a micrometer rather than digital software to measure the marginal gap. This can be a possible explanation for the higher variability of measurements compared to the Renne study.[3] While a digital software analysis system may be a more ideal measurement system, the use of a micrometer revealed that accurately identifying the true location of the marginal gap is not an exact science. The replica technique is relatively easy to perform but its accuracy may not be as great as other studies that utilize dye penetration[4,8], a computerized digital image analysis system[6], capturing digital images of marginal gap[7,10], or utilizing a scanning electron microscope[9].

While the null hypothesis was rejected, it is important to point out that the other sites revealed that the difference in fit was not large. The mesial and distal sites had a difference that

was not statistically significant. As stated above, all sites for both CAD and Press were less than 120 μm. In fact, the mean marginal gaps for all sites were less than 100 μm regardless of fabrication method. Since restoration failure can be attributed to marginal leakage at open margins greater than 120 μm[13], practitioners can feel confident in placing CAD/CAM restorations provided they follow preparation guidelines.

Conclusion

Both restorations provide marginal fit well below 120 μm provided preparation guidelines are followed. Within the limitations of this study, it can be concluded that pressable lithium-disilicate provide smaller marginal gaps than CAD/CAM lithium-disilicate crowns with only facial margins being statistically significant.

References

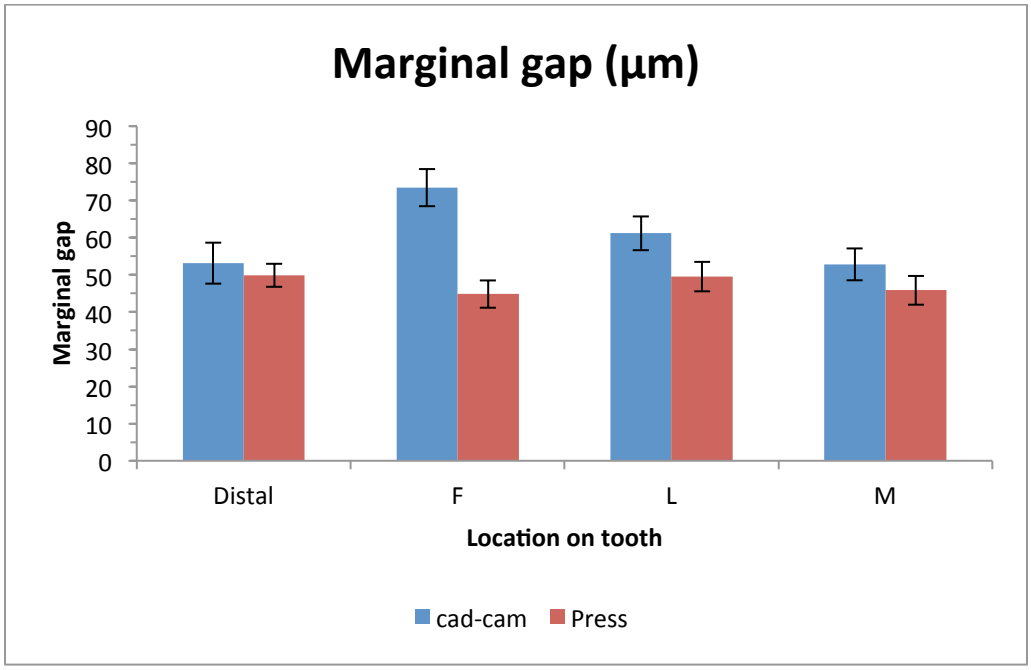
1. Bayne SC, Heymann HO. CAD/CAM in dentistry: present and future applications. Quintessence Int 1996;27:431-3.
2. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin N Am 2011;55:559-70.
3. Renne W, McGill ST, Forshee KV, DeFee MR, Mennito AS. Predicting marginal fit of CAD/CAM crowns based on the presence or absence of common preparation errors. J Prosthet Dent 2012;108:310-15.
4. Abhoushelib MN, Elmahy WA, Ghazy MH. Internal adaptation, marginal accuracy and microleakage of a pressable versus a machinable ceramic laminate veneers. J Dent 2012;40:670-7
5. Addi S, Hedayati-Khams A, Poya A, Sjogran G. Interface gap size of manually and CAD/CAM-manufactured ceramic inlays/onlays in vitro. J Dent 2002;30:53-8.

6. Baig MR, Tan KBC, Nicholls JI. Evaluation of the marginal fit of a zirconia ceramic computer-aided machined (CAM) crown system. J Prosthet Dent 2010;104:216-27.
7. Hamza TA, Ezzat HA, El-Hossary MMK, Katamish HAEM, Shokry TE, Resnstiel SF. Accuracy of ceramic restorations made with two CAD/CAM systems. J Prosthet Dent 2013;109:83-7.
8. Keshvad A, Hooshmand T, Asefzadeh F, Khalilinejad F, Alihemmati M, van Noort R. Marginal gap, internal fit, and fracture load of leucite-reinforced ceramic inlays fabricated by CEREC inLab and hot-pressed techniques. J Prosthodont 2011;20:535-40.
9. Reich S, Gozdowski S, Trentzsch L, Frankenberger R, Lohbauer U. Marginal fit of heat-pressed vs CAD/CAM processed all-ceramic onlays using a milling unit prototype. Oper Dent 2008;33(6):644-50.
10. Tan PL, Gratton DG, Diaz-Arnold AM, Holmes DC. An in vitro comparison of vertical marginal gaps of CAD/CAM titanium and conventional cast restorations. J Prosthodont 2008;17:378-83.
11. Tsitrou EA, Northeast SE, van Noort R. Evaluation of the marginal fit of three margin designs of resin composite crowns using CAD/CAM. J Dent 2007;35:68-73.
12. ADA Council on Dental Materials, Instruments, and Equipment. ANS/ADA specification no. 8 for zinc phosphate cement. 15 Sept 1977.
13. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. Br Dent J 1971;131:107-11.
14. Gehrt M, Wolfart S, Rafai N, Reich S, Edelhoff D. Clinical results of lithium-disilicate crowns after up to 9 years of service. Clin Oral Invest 2013;17:275-84.

15. Guess PC, Selz CF, Steinhard YN, Stampf S, Strub JR. Prospective clinical split-mouth study of pressed and CAD/CAM all-ceramic partial coverage restorations: 7-year results. Int J Prosthodont 2013;16:21-5.
16. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. J Prosthet Dent 1989;62:405-8.

Figure 1

Figure 2



error bars represent ± 1 standard error

Table 1

						p-value
Site/group	**mean**	**std**	**median**	**min**	**max**	**t-test**
Distal						
cad-cam	**53**	**28**	**53**	**12**	**141**	**0.605**
Press	**50**	**15**	**49**	**22**	**90**	
Facial						
cad-cam	**73**	**25**	**68**	**39**	**141**	**<0.001**
Press	**45**	**18**	**36**	**19**	**82**	
Lingual						
cad-cam	**61**	**23**	**61**	**24**	**114**	**0.058**
Press	**49**	**20**	**44**	**17**	**87**	
Mesial						
cad-cam	**53**	**22**	**51**	**22**	**102**	**0.235**
Press	**46**	**19**	**44**	**15**	**87**	
***n=25 teeth per location and measurement method.**						

Table 2

Site/group	**Intraclass correlation coeffient**	**95% LB**
Distal		
cad-cam	0.92	0.87
Press	0.83	0.73
Facial		
cad-cam	0.92	0.87
Press	0.86	0.78
Lingual		
cad-cam	0.85	0.76
Press	0.83	0.74
Mesial		
cad-cam	0.88	0.81
Press	0.83	0.73